APPENDIX F

COMPUTATION FOR DESIGN OF FLIP BUCKET AND ROLLER BUCKET

F-l. Introduction. The following example will illustrate some of the procedures and guidance provided by this manual for the design of flip buckets and roller buckets. The example will show:

a. Computations for design of flip bucket geometry.

b. Computation of pressure acting on the invert of the flip bucket.

c. Computation of the flip bucket jet trajectory.

d. Computations for design of a roller bucket.

F-Z. Design Considerations. Alternative designs for a flip bucket at the downstream end of the chute spillway described in Appendix E and a roller bucket at the toe of an overflow spillway similar to that described in Appendix D are required. Design criteria and geometric conditions are:

Spillway face slope	1V:lH
Chute slope S	0.05 ft/ft
Chute and flip bucket width	88 feet
Discharge	66,200 ft^3/sec
Depth of flow entering bucket d_1	9.5 feet
Bucket invert elevation	1,375 feet*
Spillway design flood tailwater elevation	1,330 fees
Allowable foundation bearing pressure	2 kips/ft

F-3. Computations.

a. Flip Bucket Geometry. See Paragraph 7-18.

(1) Bucket radius.

$$r_{min} = \frac{\rho V_1^2 d_1}{P_T - \gamma d_1} \qquad \text{(Equation 7-3)}$$

$$V = \frac{Q}{A} = \frac{66{,}200}{(88)(9.5)} = 79.2 \text{ ft/sec}$$

$$r_{min} = \frac{1.94(79.2)^2 (9.5)}{2{,}000 - 62.4(9.5)} = 82 \text{ feet}$$

Use r = 100 feet

* All elevations cited herein are in feet referred to the National Geodetic Vertical Datum (NGVD).

(2) Minimum bucket height.

$$h_{min} = r - r \cos (\phi - \tan^{-1} S) \qquad \text{(Equation 7-4)}$$

where

$$\phi = \tan^{-1} \left\{ \frac{\left[d_1 (2r - d_1)\right]^{1/2}}{r - d_1} \right\}$$

$$= \tan^{-1} \left(\frac{\left\{ 9.5 \left[(2)(100) - 9.5\right]\right\}^{1/2}}{100 - 9.5} \right)$$

$$= 25.2'$$

$$h_{min} = 100 - 100 \cos (25.2 - \tan^{-1} 0.05)$$

$$= 7.48 \text{ feet}$$

Use h = 7.5 feet

and elevation = 1,375 + 7.5 = 1,382.5

(3) Trajectory angle resulting from the minimum flip bucket height. Angles greater than the minimum can be used by increasing the bucket height.

$$h = r - r \cos \theta \qquad \text{(Equation 7-5)}$$

$$= \cos^{-1} \left(\frac{r - h}{r} \right)$$

$$= \cos^{-1} \left(\frac{100 - 7.5}{100} \right)$$

$$= 22.3^{\circ}$$

b. Flip Bucket Jet Trajectory Characteristics

(1) Horizontal distance, lip to impact area

$$X_H = h_e \sin 2\theta + 2 \cos \theta \left[h_e (h_e \sin^2 \theta + Y_1)\right]^{1/2}$$

$$= 217.3 \text{ feet}$$

(2) Impact angle

$$\theta' = \tan^{-1} \left[\sec \theta \left(\sin^2 \theta + \frac{Y_1}{h_e} \right)^{1/2} \right] \qquad \text{(Equation 7-8)}$$

$$= 41.8^{\circ}$$

c. Roller Bucket Design.

(1) Assumptions:

Pool elevation	1,500 feet
Spillway toe elevation	1,245 feet
Spillway energy loss from boundary layer computation as illustrated in Appendix E	5 feet
Spillway unit discharge q	752.3 ft^3/sec

(2) Bucket radius

$$r_{min} = \frac{5.19\left(d_1 + \frac{V_1^2}{2g}\right)}{F_1^{1.64}}$$

$$H = 1{,}500 - 1{,}245 - 5 = 250 \text{ feet} = d_1 + \frac{V_1^2}{2g}$$

By trial $V_1 = 125.3$ ft/sec , $d_1 = 6$ feet , $F_1 = 9$

$$r_{min} = \frac{5.19(250)}{9^{1.64}}$$

$= 35.3$ feet

Use r = 40 feet

(3) Bucket invert elevation limits

(a) Maximum depth invert elevation (Plate 7-5)

$F_1 = 9.0$

$$\frac{r}{d + V_1^2/2g_1} = \frac{40}{250} = 0.16$$

Maximum tailwater depth $h_2(max)$

$= 15d_1$

$= 15(6)$

Elevation = 90 feet = 1,330 - 90

= 1,240 feet

(b) Minimum depth elevation (Plate 7-6)

Minimum tailwater depth $h_2(min)$

$= 13.7d$

$= 13.7(6)$

$= 82$ feet

Elevation $= 1,330 - 82$

$= 1,248$ feet

Bucket invert elevation of 1,245 feet is acceptable.

(4) Roller depth (Plate 7-7)

$h_2 = 1,330 - 1,245 = 85$ feet

$h_1 = 1,500 = 1,245 = 255$ feet

$h_2/h_1 = 85/255 = 0.33$

$$\frac{q \times 10^3}{g^{1/2}\ h_1^{3/2}} = \frac{752 \times 10^3}{(5.67)(4,082)}$$

$= 32.6$

$h_b/h_1 = 0.2$ where h_b is the roller height

$h_b = 0.2(255) = 51$ feet

Elevation of roller $= 1,245 + 51 = 1,296$ feet

(5) Surge height (Plate 7-8)

$h_b/h_1 = 51/255 = 0.2$

$h_s/h_1 = 0.44$

$h_s = 0.44(255) = 112$ feet

Elevation of surge $= 1,245 + 112 = 1,257$ feet

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